Fermilab

SDC Solenoid Design Note #155
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Magnetostatic Analysis of Iron HAC1 and Lead HAC1 Calorimetry for SDC

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Introduction

The two scintillating fiber calorimeters for SDC differ significantly in the design of the HAC1 (HAdron Calorimetry) region. One option contains lead only in this region, and is designated Lead HAC1 for this report. The other option contains only iron, and is designated Iron HAC1. The purpose of this study is to determine the compressive solenoid forces, the decentering forces, and the field uniformity of the two designs.

Finite Element Models

The two geometries are shown in Figs. 1 and 2. The coil is identical in each case. The calorimetry consists of iron or lead plates separated by air gaps. Axisymmetric ANSYS finite element models were made in which each plate and slot were modeled explicitly in the endplug region. This detailed modeling was also employed in the barrel region for the Iron HAC1 case. However, in the case of the Lead HAC1 a modified B-H curve was used to simulate the permeability of the iron/air combination, allowing larger elements representing a large volume of iron/air.

The details of the mesh in the endplug region are shown in Fig. 3.

Results

The resulting flux plots are shown in Fig. 4. The integral Bxdl for a particle originating at the vertex and traveling along a straight path to the inner radius of the solenoid is plotted for each geometry in Fig. 5. The Iron HAC1 design, with the iron endcap at 50 cm from the coil, shows somewhat better uniformity of integral Bxdl than the Lead HAC1 geometry, which has it's endcap iron 145 cm from the coil.

The axial compressive forces on the coil are 1630 tonnes and 1110 tonnes for the Lead HAC1 and Iron HAC1 geometries, respectively. Since the field in the solenoid is 2 T over a cross sectional area of 10.2 m^2, the total force acting on the solenoid and the endcap will in each case sum to approximately $10.2(B^2)/(2*mu)$, or 1660 tonnes. Therefore, the force on the endcap is approximately 30 tonnes and 550 tonnes for the Lead HAC1 and Iron HAC1 geometries, respectively.

The inability to ensure that the magnetic centers of the solenoid and the calorimetry will coincide after installation requires the calculation of decentering forces. If it is assumed that the solenoid will be at most 2.5 cm off center both radially and axially from the magnetic center of the calorimetry, the resulting forces for the Lead HAC1 geometry are 4 tonnes and 17 tonnes, for radial and axial force, respectively. The forces for the iron HAC1 geometry are 5 tonnes and 60 tonnes, for the radial and axial force, respectively. The closer proximity of the iron to the coil, which aids field uniformity, also causes the flux to be more sensitive to iron position in the Iron HAC1 design, leading to higher forces.

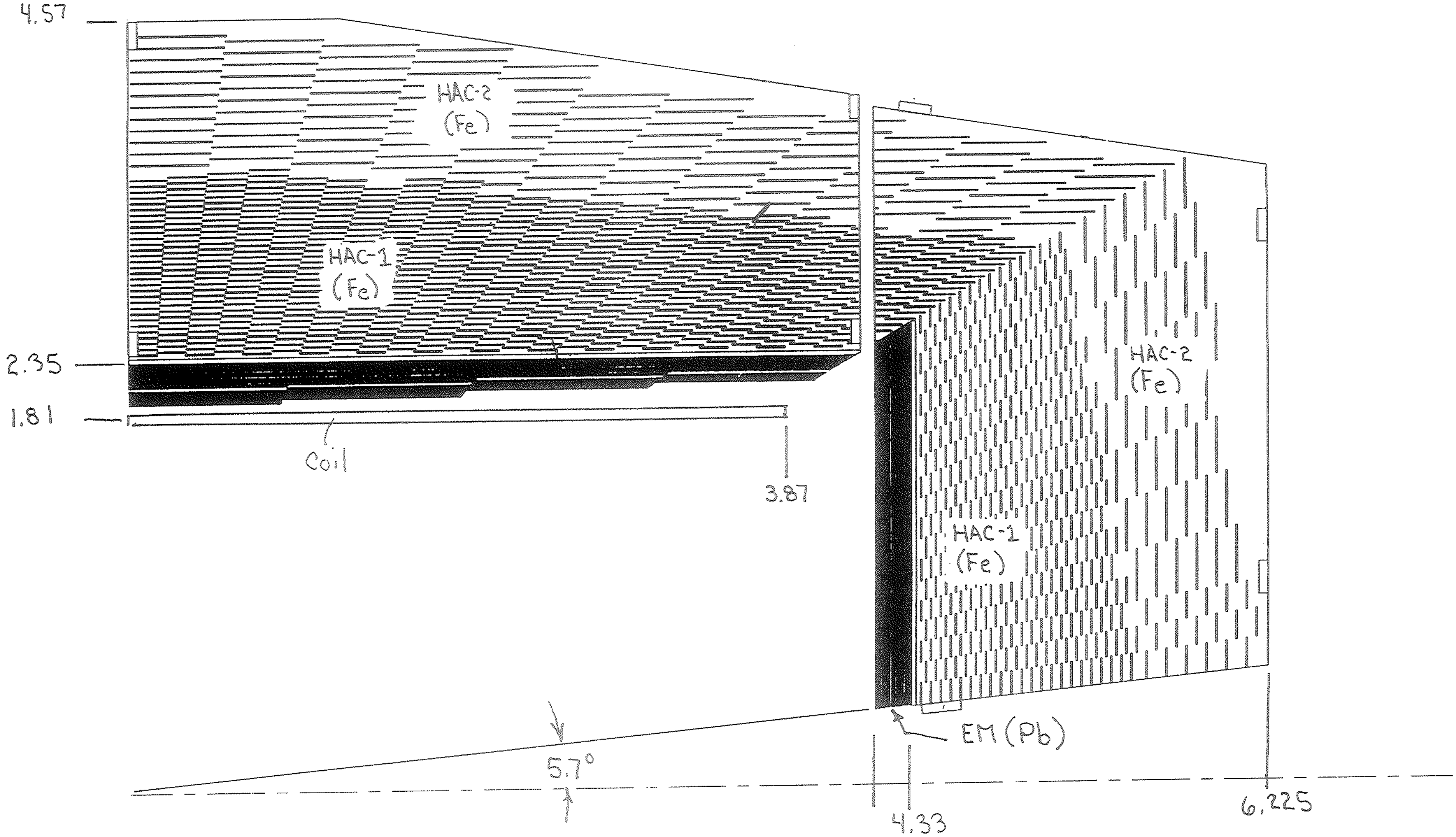

Fig. 1. Iron HAC1 Geometry

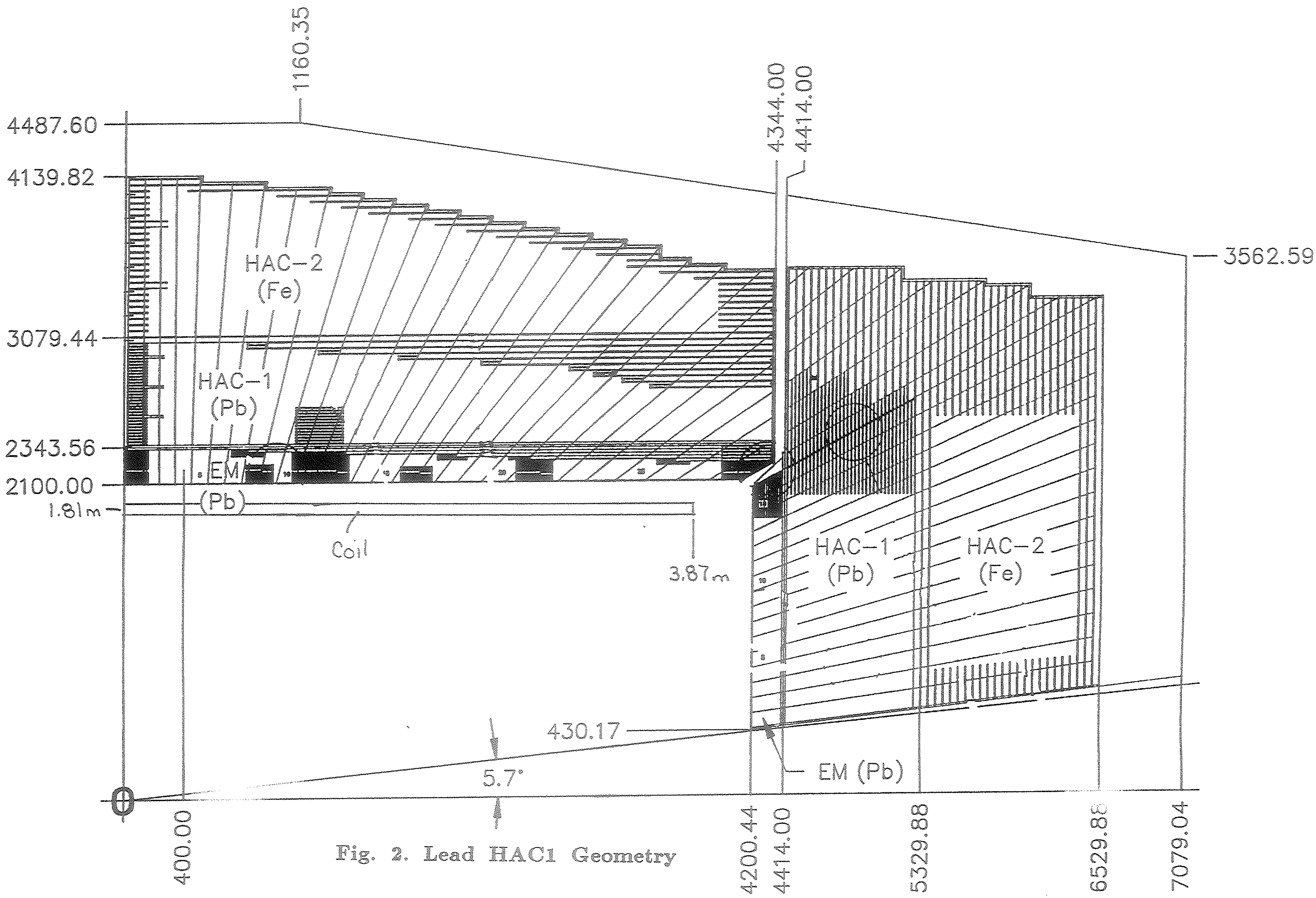

Fig. 2. Lead HAC1 Geometry

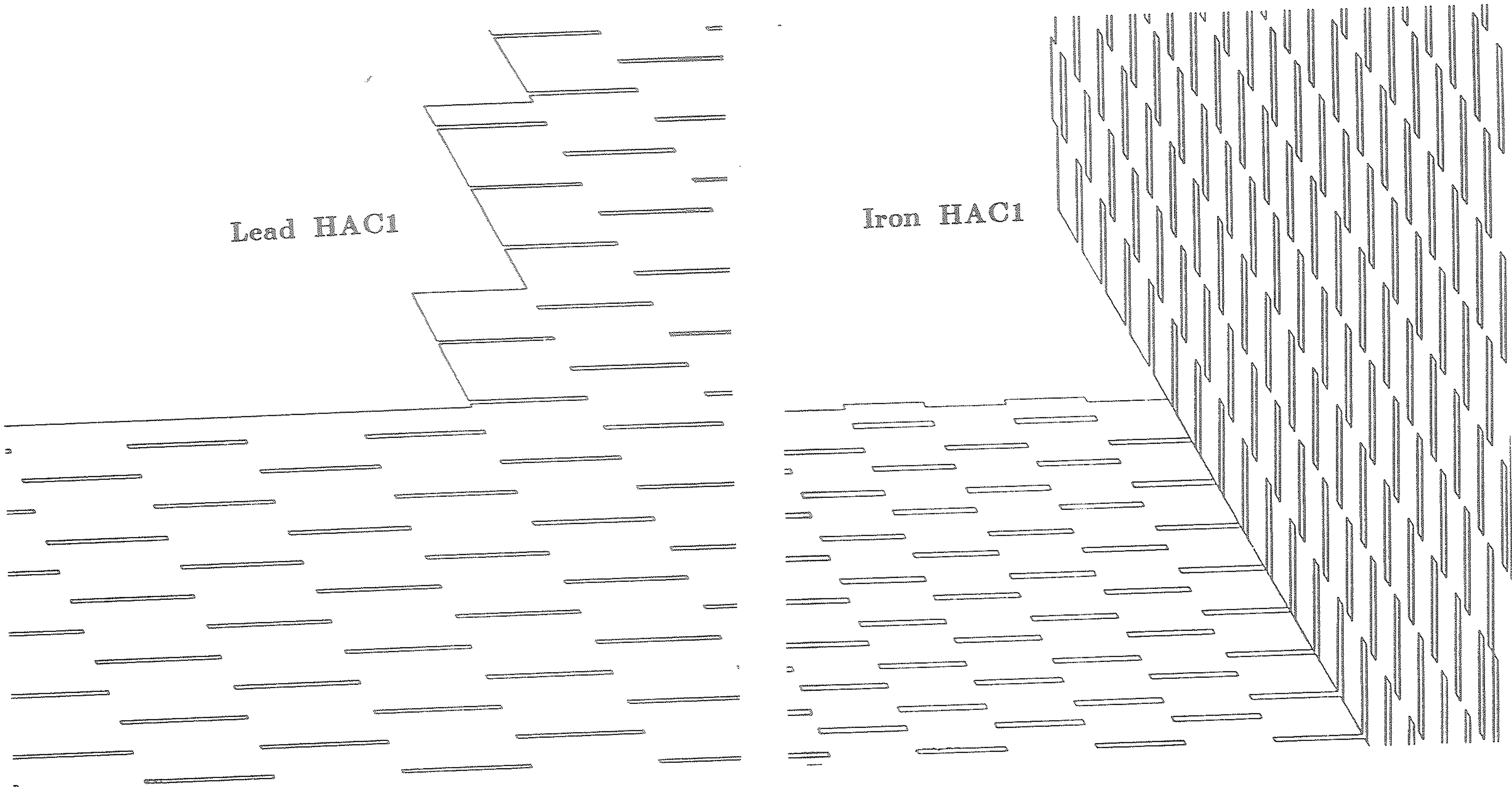

Fig. 3. Slot Details from Finite Element Analyses

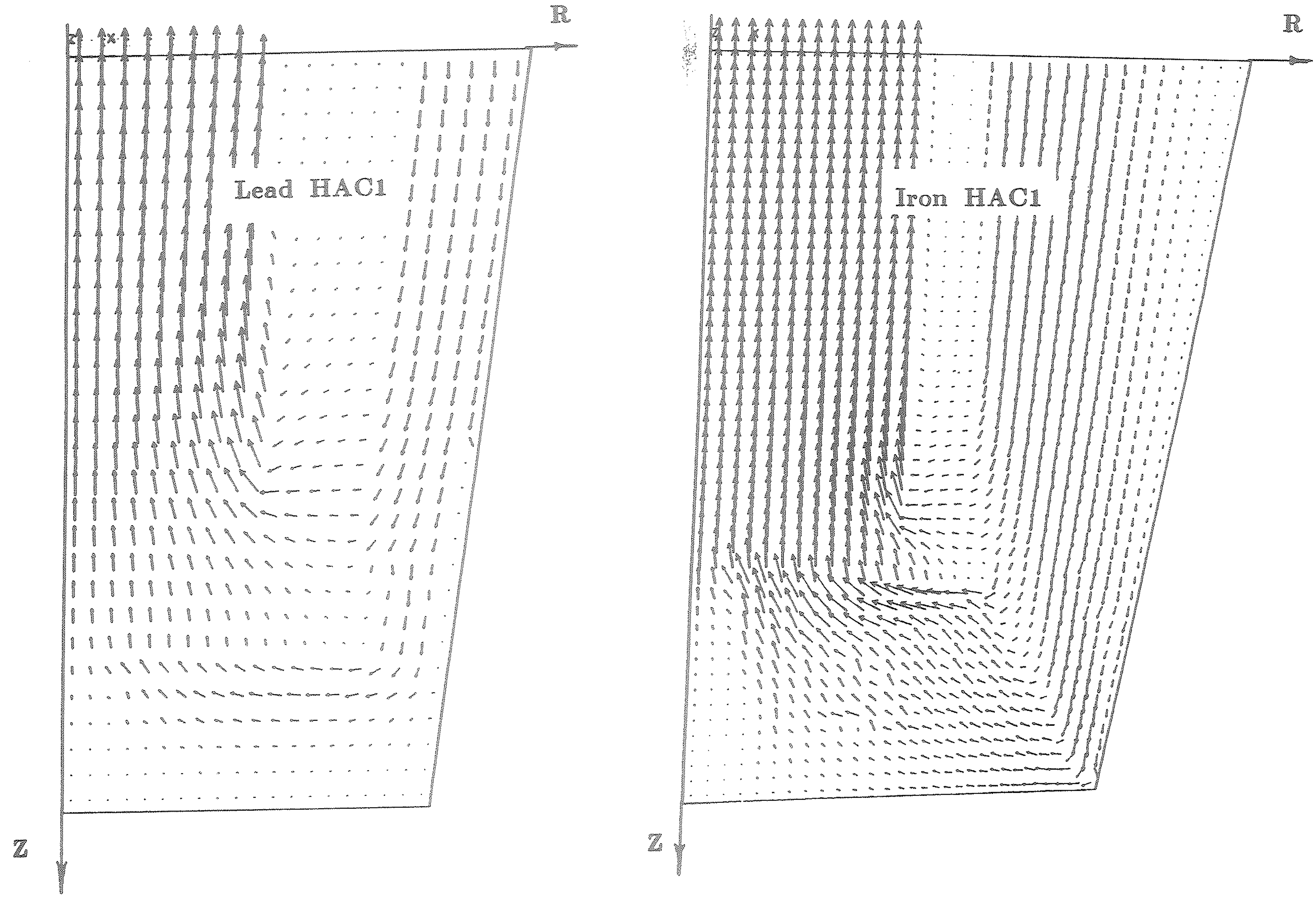

Fig. 4. Flux Plots

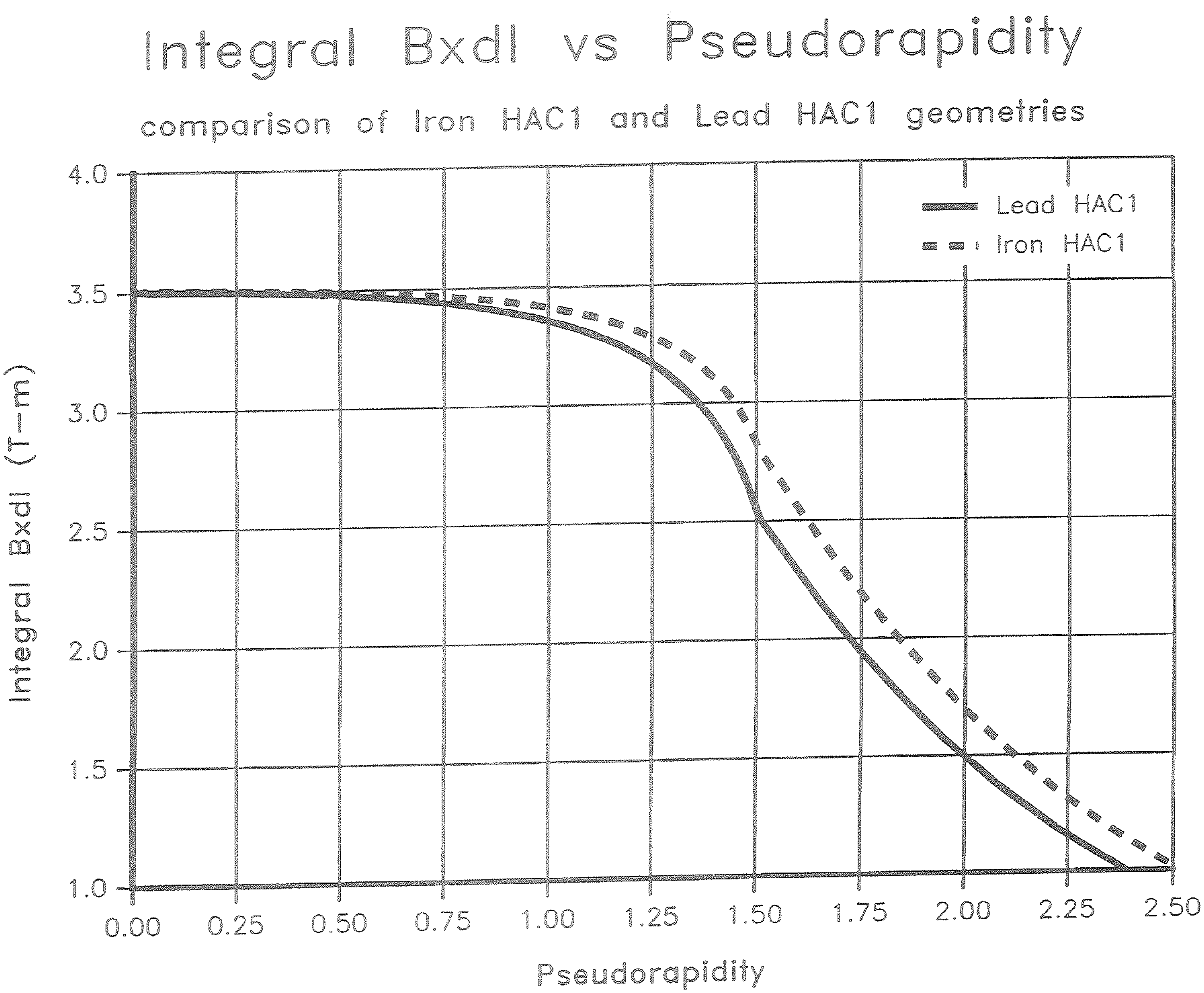
Integral Bxdl vs Pseudorapidity
comparison of Iron HAC1 and Lead HAC1 geometries
Lead HAC1
Iron HAC1
Integral Bxdl (T—m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
Pseudorapidity

Fig. 5.